IN THE SPECIFICATION

Please amend the specification as follows:

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The present invention addresses <u>some of</u> the shortcomings of the related art discussed above. The present invention provides an accurate measurement of fluid density in a downhole environment. The present invention places an acoustic transducer in contact with a "near wall" whose acoustic impedance is much different than the impedance of the fluid to be measured. The transducer launches an acoustic pulse into this near wall (such as a plate, a wall of a tube, or a wall of a sample chamber). The other side of this near wall is in contact with a sample of unknown fluid. After sending out an acoustic pulse, this same transducer acts as a receiver to monitor the reverberations of this acoustic pulse within this near wall.

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As can be seen from Figs. 2-4 of the present invention, the reflected acoustic energy is not concentrated into a single cycle as shown in the idealized illustration of Fig. 2 of <u>the</u> '693 <u>patent</u> but is distributed over several cycles. Also, the distribution of reflected energy between the largest amplitude cycle and its neighboring cycles within the same pulse is not constant but changes from pulse to pulse and reflection to reflection, which could be a significant source of inaccuracy in the '693 measurement.

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In an air-filled titanium tube, ignoring small effects of attenuated reflection due to air's high absorption of ultrasound, the reflection at the air/wall interface is approximately 100% because titanium, or any metal, has substantially greater acoustic impedance than air. Thus, we can calculate the reflection coefficient at the

transducer/wall interface using the pulse energy decline slope of an air-filled tube as a reference value. Then, using this reflection coefficient at the transducer/wall interface, we can then calculate the reflection coefficient at the fluid/wall interface for an unknown fluid from the slope of the logarithm of the pulse echo energy versus pulse echo number. Because we know the acoustic impedance of the wall material, we can then use the measured reflection coefficient at this fluid/wall interface to calculate the acoustic impedance of the unknown fluid inside the wall. Finally, we calculate the fluid's density by dividing its measured acoustic impedance by its measured sound speed as explained immediately below.

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FIG. 1 illustrates a laboratory validation experiment in which the ~~density~~ densities of two fluids, dodecane and water, were determined to demonstrate some of the principles of the present invention;

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R_{WF} = Fraction of energy reflected at Wall/Fluid interface

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Finally, because the acoustic attenuation of fluids increases with their viscosities, we can, in principle, estimate fluid viscosity by measuring the attenuation across the inner diameter of the tube. The attenuation can be inferred from the discrepancy between the actual reflected signal and the expected value of an unattenuated reflected signal as calculated from measured R_{TW} and R_{WF}). To be sure of actually monitoring attenuation,

~~to~~ the example of the present invention uses acoustic pulses at more than one frequency because the attenuation increases as a power of frequency.

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Turning now to **FIG. 10**, an example of the functions performed by the present invention is illustrated. As shown in block **1001** the present invention captures a fluid sample in a flow line from the formation or the borehole. In block **1003** the present invention then sends an acoustic pulse into the fluid sample in the flow line or sample tank. The processor of the present invention then monitors the echo returns within the wall of the flow line or sample tank and integrates the energy of each acoustic echo pulse. The processor determines the slope of the decay of the integrated acoustic echo pulses bouncing inside of the wall of the flow line. In block **1007** the present invention then determines the reflection coefficient for the inner wall/fluid interface. In block **1009** the present invention determines the speed of sound in the fluid. In block **1011** the present invention determines the density of the fluid in the <u>flow</u> line as described above. In block **1013** the present invention determines the viscosity of the fluid in the flow line as described above.

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The ~~preferred~~ <u>exemplary</u> embodiment of the present invention provides an acoustic pulsing device on the outer wall of a small sample flow tube through which fluid from the formation or wellbore is being pumped. This sample tube wall is not thick enough to allow for an internal reflection slot (a void) of the type described in U.S. patent number 6,189,383 (the '383 patent). Also, the time windows for integration in the '383 patent (Figs. 5 and 6 of '383) are overlapping and they include more than one pulse echo

unlike the present invention, in which ~~requires that~~ integration ~~be done~~ performed over each individual pulse without any overlap. The present invention fits a line between the echo number and the logarithm of the energy in each echo, ~~which is not possible if one integrates~~ as opposed to integrating over more that one pulse echo, as ~~is~~ done in the '383 patent. The present invention does not need an internal reflection slot because it is the slope of this best fit line that indicates the acoustic impedance of whatever fluid is in contact with the tube wall.

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The present invention is more accurate than prior attempts to determine density of unknown fluids such at that described U.S. patent number 5,741,962 (the '962 patent). In the '962 patent, reflection coefficients and the corresponding fluid density are calculated from peak-to-peak amplitudes (**FIGS. 4A** and **4B** of the '962 patent), which can be very unreliable and prone to aliasing, sampling, and other experimental measurement errors. **FIG. 11** shows the poor results of applying the method of '962 patent to the lab verification experiment of the present invention. It plots the logarithm of the square of the maximum amplitude swing within ~~once~~ one cycle against pulse echo number. Now, instead of the high coefficients of determination (R^2>0.99 in **FIG. 5**) obtained by the pulse-integration method of the present invention, the coefficients of determination vary from $R^2 = 0.65$ to $R^2 = 0.73$ and the points do not lie close to the best fit lines **1102**, **1104**, and **1106**. The reason is that the '962 patent, like '383 patent, describes using an idealized signal ~~for illustration~~. Only if the pulse shape remained completely unchanged from pulse-to-pulse (or from echo-to-echo of a single pulse) would the square of the peak-to-peak amplitude remain proportional to the integrated peak energy. However, from the experimental data in Figures 2-4 of this invention it is clear that successive pulse

echoes are not simply rescaled copies of the previous pulse but that they undergo distortion, which causes the square of the peak amplitude swing to be an unreliable indicator of total pulse energy. The present invention estimates the energy under an entire pulse rather than relying on a single transient peak amplitude. Thus the present invention provides a more accurate method and apparatus than relying on a transient peak amplitude as in the '962 patent.

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While the foregoing disclosure is directed to the preferred embodiments of the invention various modifications will be apparent to those skilled in the art. It is intended that all variations within the scope of the appended claims be embraced by the foregoing disclosure. Examples of the more important features of the invention have been summarized rather broadly in order that the detailed description thereof that follows may be better understood, and in order that the contributions to the art may be appreciated. There are, of course, additional features of the invention that will be described hereinafter and which will form the subject of the claims appended hereto. The above example of ~~a~~ ~~preferred~~ an embodiment of the invention has been provided for illustration purposes only and is not intended to limit the scope of the invention, which is determined by the following claims.